ISRAELI NATIONAL AERIAL DATA CAPTURING STANDARD FOR GENERATION OF DIGITAL GEOSPATIAL PRODUCTS AT NATIONAL SCALE

[a]Eran Keinan, [a]Noam Shwarts*, [a]Ofer Siman Tov, [a]Hagi Ronen, [b]Ronen Regev

[a] Survey of Israel, Lincoln 1, Tel-Aviv, 61141- (eran, noam, oferst, hagi)@ mapi.gov.il
[b] ronen.regev@gmail.com (former Survey of Israel Director General)

Commission II, WG II/1

KEY WORDS: NMCA, digital photogrammetry, ortho imagery, GCP, GSD, DSM, DTM, point cloud.

ABSTRACT:

Digital camera systems are a key component in the production of reliable, geometrically accurate, high-resolution geospatial products in a national scale. These systems have replaced film imaging in photogrammetric data capturing. Today, we are witnessing a proliferation of imaging sensors, collecting images in different ground resolutions, spectral bands, swath sizes, radiometric characteristics and accuracies being carried on varied mobile platforms. In addition, these imaging sensors combined with navigational tools (such as GPS and IMU), active sensors such as laser scanning and powerful processing tools, to obtain high quality geospatial products. The quality of these geospatial products based on the utilization of calibrated, high-quality digital camera systems.

The new Survey of Israel (SOI) regulations specify the quality requirements for each geospatial product including maps at different scales and for different purposes, elevation models, ortho imagery etc. In addition, the regulations require that digital camera systems utilized for mapping purposes should be certified, using a rigorous mapping systems certification and validation process, which are specified in the SOI Director General Instructions (DGI).

In 2019 the SOI has updated the camera certification and validation procedure and published a new national aerial capturing standard for digital geospatial products as a basis for the public bid in three main fields:

1. Aerial data capturing including ground control points (GCP) measurements and aerial triangulation.
2. Ortho imagery in several ground resolution distance (GSD) and several projections.
3. Digital Elevation models including: points clouds, Digital Surface Model (DSM) and Digital Terrain Model (DTM).

This article provides the details of the Israeli Directive for camera certification and Standard for digital geospatial products including the main technical requirements of the public bid that was carried out.

1. INTRODUCTION

The ASPRS publish new standard (ASPRS et al., 2014) that addresses geo-location accuracies of geospatial products with no intention to cover classification accuracy of thematic maps. The standard does not specify the best practices or methodologies needed to meet the accuracy thresholds. The ASPRS standard is intended to use by geospatial data providers and users to specify the positional accuracy requirements for final geospatial products.
Land Information of New Zealand (LINZ) also publish a Standard for nationwide Orthophoto capturing addressing capturing standards, product delivery guidelines and quality assurance standards for Orthophoto products (LINZ et al., 2013) but it didn't address the means to achieve the accuracy goals.

The Survey of Israel Regulations directivities include new definitions for mapping products, new requirements for quality (accuracy and content) of these products and an update of the procedures, methods and technologies. These regulations also provide the details for utilization of digital mapping platforms including the validation, calibration and certifications of these platforms (Felus et al., 2016). In 2019 the SOI published a new Director General Instruction refining the process of mapping systems certification and validation.

It is agreed by all, that the most important topic is to define the accuracy of the final products. However, in the perspective of National Mapping and Cadaster Authority (NMCA) it is very important to define a clear, reliable and practical standard as a basis for a public bid in cases that the NMCA's use the global\local market to generate the geospatial products.
The objectives of the standard are:

1. Correlate with digital sensors in order to generate geospatial products.
2. Generate eco system based on the professional capacities of the local market and the governmental and public needs.
3. Support dissemination of up to date geospatial products (Ortho imagery, Digital Elevation models etc.) annually.

This article presents a practical approach taken in Israel. Section 2 describe the main regulations and the new Director General Instruction (DGI) that influence the standard. Section 3 describe the main topics of the Israeli National Standard for national aerial data acquisition and geospatial products. Section 4 concludes the report with a description of the public bid carried out, and further work to be carried out on the topic.

* Corresponding

2. MAPPING REGULATIONS AND DIRECTOR GENERAL IN ISRAEL

Mapping and surveying procedures and technologies are regulated in Israel since 1929 when the British Mandate enacted the Survey Ordinance. This Ordinance necessitate the publication of the Survey Regulations as the official document that defines and regulates the surveying work and the publication of the DGI that provide the technical details about the methodology and technologies (Felus et al, 2016).
As mentioned above, this section describe the main regulations and DGI in the field of geo information and mainly in the field of digital photogrammetry and geospatial products.

2.1 Digital Camera Certification

The certification process was describe in details at the National guidelines for digital camera systems certification by Felus et al. (2016). In 2019 he SOI established and maintain a new certification test field in Netanya, in order to check and certify digital camera systems. The test field, consists of more than 200 ground control points measured in very high accuracy, for the certification process. Figure (1) describe the process and present the test field:

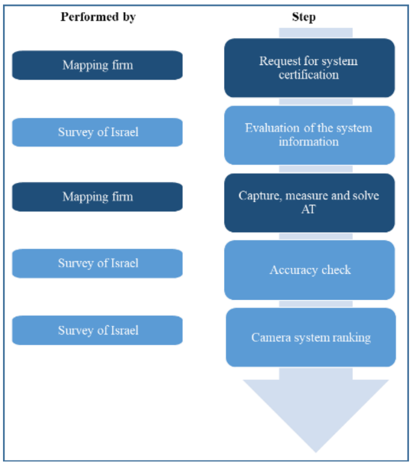

Figure (1a): *Certification process*

Figure (1b): *Certification test field, Netanya*

The DGI ranking digital camera systems for mapping is based on the Survey Regulation requirements. Based on the main characteristics, the ranking determination is implemented to the digital camera system as describe in Table (1):

Criteria\Ranking	A	B	C	D
aircraft	airplane	airplane	airplane	UAV
gyro stabilizer	✓	×	×	×
FMC	✓	×	×	×
max radial distortion µm	6	12	24	40
IMU	✓	×	×	×
GNSS	DGPS	GPS	×	×
Image format	large	medium	small	small

Table 1: Ranking and Criteria of Digital Aerial Systems

The ranking of the digital camera system done by all accumulate criteria's. Furthermore, the digital camera system ranking is not the tool to achieve the final accuracy. In order to deal with the accuracy of the product each digital camera system was checked and certified, i.e.: a digital camera system that its ranking defined as B is also certify to mapping in high accuracy, the same as another system with A ranking. More details on the accuracy of the final products and the SOI regulations were already describe by Felus et al. (2013).

2.2 Density and Accuracy of GCP and AT Accuracy

The main factors that directly influence the accuracy of the geospatial products produced by digital camera systems for engineering purposes (i.e. construction permit maps) are:

1. The accuracy of the ground control points.
2. The density of the ground control points.
3. The accuracy of the Aerial Triangulation solution.

This sub section will describe the DGI topics in order to assure that the quality of the final products meets the SOI regulations. In order to achieve the accuracy the DGI use the assumption that the accuracy of the ground control points, in terms of RMSE, should be half of the final accuracy.

The ASPRS already refer to distribution of GCP (ASPRS et al., 2004) The DGI use the recommendation of the ASPRS as a basis for the determination of the amount and distribution of the ground control points define as follow:

1. Each GCP should be located only in a stereoscopic coverage.
2. The edges of the block should be register by GCP.
3. In case of digital camera system with dual frequency DGPS:
   a. Each strip in the edged of the block should be register by GCP every sixth image.
   b. In transition strips, every sixth image should be register by GCP.
4. In case of digital camera system with single frequency GPS:
   a. Each strip in the edged of the block should be register by GCP every fourth image.
   b. In transition strips, every fourth image should be register by GCP.

Figure (2) illustrate the principles of the amount and distribution of the GCP's:

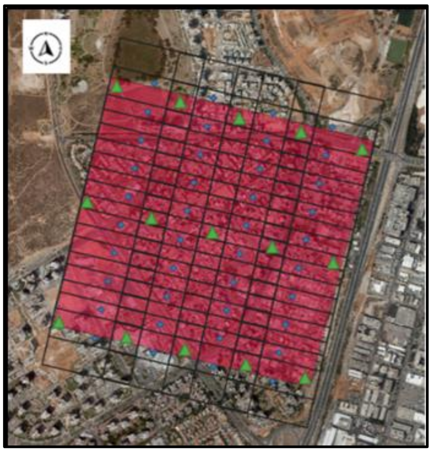

***Figure (2a)**: distribution of GCP for dual frequency GPS*

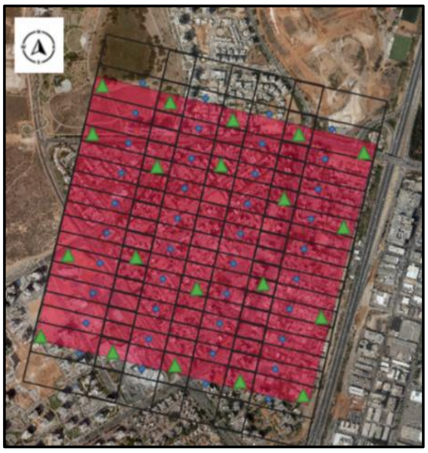

***Figure (2b)**: distribution of GCP for single frequency GPS*

As mentioned above the accuracy of the AT is also a key component for assure the final quality of the final geospatial product. Table (2) describe the accuracy levels, GSD and the RMSE of the GCP and AT (see Annex 1).

3. MAIN TOPICS ISRAELI NATIONAL AERIAL DATA CAPTURING STANDART FOR GENERATION OF DIGITAL GEOSPATIAL PRODUCTS

Israel is a small country in terms of size (~28,000 km^2) but characterized by rapid development and construction. These changes lead to demand from the Israeli Governmental Inter Office Committee for GIS to produce geospatial products (i.e. ortho imagery) in a national scale annually.
This demand lead us to promote a new standard, which utilize for the public bid. The standard divided into 3 main chapters:

1. Chapter A – describe the definition for digital camera systems, aerial data capturing, GCP establishment and measuring, AT solution and quality control.
2. Chapter B - describe the definition for ortho imagery generation (geometric and radiometric) and quality control.
3. Chapter C - describe the definition for elevation models generation and quality control.

The next sections will describe the main topics of each chapter.

3.1 Chapter A

3.1.1 Digital Camera Systems

The camera system must be categorized level A with accuracy level 5 approved by the DGI. The digital camera system must be mounted on a 3 execs stabilizer and have panchromatic and multi spectral channels (RGB & NIR)

3.1.2 Aerial Data Capturing

The Aerial data capturing must be performed with clear sky (no clouds or clouds haze) during the mounts March to August and between the hours 10:30- 14:30 depending the month. Capturing months and hours were set by the principle of keeping the sun angle at 45 degrees from the horizon or higher to achieve minimum shadow effect.
The maximal allowed exposers angles are: 3° for roll and pitch, 5° for heading.
Table (3) describe the overlap percentages*:

Area type	Forward overlap	Side overlap
Rural	60%	30%
Urban	80%	40%
Dense Urban	80%	60%

Table 3: Forward and side overlap

*One of the Standard annexes is a map of Urban and Dense Urban areas to be captured at higher overlap. The map is also provided in a form of a SHP file.

3.1.3 Ground Control Points

The amount of ground control points and the distribution must be according to the DGI as follow:

a. Each strip in the edged of the block should be register by GCP every sixth image.
b. In transition strips, every sixth image should be register by GCP.

The ground control points must be visible and stable manmade objects lower than 1 meter from the ground (preferably road markings, edge of pavement, edge of manholes etc.) In open areas, the centre of small bushes can be used if approved in advanced.

3.1.4 Aerial Triangulation

In order to achieve continuity and equality the aerial triangulation must be performed in blocks as big as possible (at least 500 km^2) and tie points and ground control points from surrounding blocks must be used.
The tie point's distribution will be meet Van Groover pattern and an automatic algorithm will clean any abnormal values.
Aerial triangulation results must be within the RMSE values approved by the DGI (see table 2 at Annex 1).

3.1.5 Quality Control

As mentioned earlier, the quality of the aerial imagery acquisition and the accuracy of the aerial triangulation play a key role in determining the final accuracy of imagery derived mapping products and therefor, the main purpose of this stage is assure that the Orthophoto and height elevation models are produced accurately and with no mistakes.
Most of the procedures are done automatically, running a series of tests set to validate the products are according to the standard. Table (4) describe the main testing sets:

Subject	Testing method	Procedure

Image quality	manually	No clouds or clouds shadows, No blurred images
Capturing hours	automatically	Hours defined in the standard by month
Overlap	automatically	Checking the overlap with reference to the urban/dense urban areas
Exposure angles	automatically	Roll& Pitch $\leq 3^{\circ}$ Heading $\leq 5^{\circ}$
GCP spread	automatically	Checking the spread with reference to the images footprints
AT accuracy	manually	Stereoscopic measuring of GCP's

Table 4: QC procedures

3.2 Chapter B

This chapter describes the processing steps and procedures to generate a multi spectral Orthophoto with the accuracies set by the DGI.
The Orthophoto generation should be based on the aerial triangulation block and data from neighbouring blocks.

3.2.1 Geometric

To assure that the Orthophoto stands to the standards of the DGI in terms of geometrics, the data provider is expected to use these data sets:

a. Image parameters
b. 10 meter resolution DEM
c. Aerial triangulation report
d. Camera calibration report
e. Ground control points

The production procedure requires the ortho rectification of all images captured and a mosaicking procedure that calculates the most nadir part of each image.
The use of images and ground control points from neighbouring blocks is needed for the geometric continuity of the product.

3.2.2 Radiometric

The generation of a national scale Orthophoto captured with variant sensors and during a period of a few mounts can be very challenging in terms of color balance uniformity, in order to achieve optimized product the DGI provides basic guidelines:

a. During the aerial capture stage, every flight mission needs to be focused in one geographic area.
b. For each area captured (~5,000 km^2) all raw images needs to be color adjusted during the aerial triangulation stage (the use of tie points is highly recommended).
c. During the Orthophoto production stage, images from neighboring areas must be used in the color balance stage, in case adjective ortho blocks area captured by different sensors, the provider must also use images from the other sensor to best preform the color adjustment.

3.2.3 Quality Control

Due to the fact that the visual aspect of the Orthophoto draws most of the attention from the end users, a large amount of resources goes to the radiometric quality of the product but the geometric accuracy is not less important and focus on 2 main topics:

a. The horizontal accuracy measured in respect to known measured points located on the ground; acceptable horizontal accuracy in terms of RMSE was set to maximum$\pm 1.25_{m}$.
b. Relief displacement is measured in respect to known buildings heights in several areas in the Orthophoto, acceptable relief displacement describe in formula (1):

$$(1) \quad \begin{array}{ll} rural\ area & \min(10\% \times relatibe\ bH, 10\ meters) \\ urban\ area & \min(15\% \times relatibe\ bH, 15\ meters) \end{array}$$

Where relative bH is the relative building height above the ground.

The radiometric quality control procedures focus on the topics which describe in table (5):

Subject	Testing method	Procedure
Tone histogram	automatically	Validating the tone spread reflects the real colours of the captured area
Contrast	visually	Looking for details in areas with high light and dark shadows
Sharpness	visually	Being able to detect features according to the capture resolution
Band ratio	automatically	Checking NDVI, NWDI
Radiometric uniformity	manually	Checking uniformity of neighbouring areas

Table 5: Chapter B Radiometric QC procedures

3.3 Chapter C

This document refers only to height elevation models produced by photogrammetric methods. The production must be done semi automatically and by using the aerial triangulation data.

3.3.1 Point Clouds

The point clouds generated automatically needs to be cleaned manually of any spikes and noises, the product's minimum point spacing should be 8 points per m^2.
The point clouds needs to be classified automatically into bear earth - points describing the ground and elements of the ground such as terraces, quarries, roads etc. will be classified into ground class and points describing manmade objects such as buildings, bridges, culverts, walls etc. or vegetation will be classified into non-ground class. Manual classification is needed following the automatic procedure in order to achieve 95% validation. The automatic classification of vegetation is expected to use the color values of the point cloud (NIR values are preferred but not obliged).

3.3.2 DSM & DTM

The DTM and DSM will be calculated based on the classified point clouds- the DTM will be a regular surface describing the points classified to ground at a special resolution of 50 cm and the DSM will be a regular surface describing the points classified to ground and non-ground at a special resolution of 50 cm.

3.3.3 Quality Control

The quality control stage of the height elevation modules will be done for both the point clouds data and the DSM & DTM raster's. Point clouds will be tested to ensure the quality of the DSM & DTM and there for the objective of the procedure will be to ensure the point density and the quality of the classification.
The raster's will be tested to ensure the accuracy and reliability of the data.
Most of the procedures are done automatically running a code going over the files and flagging the mistakes but some will be done manually. Table (6) describes the procedures and their objectives:

Objective	Data set	Procedure
Point density	Point clouds	≥ 8 points per m^2
Non-ground features classification	Point clouds	See below formula (2)
Noise free DSM	DSM & DTM	nDSM clean of spikes which are not objects of the DSM (see below formula (3))
Water bodies	DSM & DTM	Water bodies must be flat and clean of noises
No data values	DSM & DTM	Only permitted at the edges of the covered area
Spatial accuracy	DSM & DTM	$RMSE\ (m)\ \leq 1.25$

Table 6: Chapter C DTM&DSM QC procedures

(2) $non - ground\ class = \{manmade\ object\}\ area \geq 6\ m^2\ \&\ rH > 2m$

Where rH is the relative height of the object from the ground surrounding it.

(3) $nDSM = DSM - DTM$

4. SUMMERY

Flowing the publication of the standard, in 2019 the SOI has issued a tender for nationwide aerial acquisition and the production of nationwide mapping products and since then has covered the country 3 times. The tender stated the minimum terms a service provider must qualify (certified camera system, minimum experience etc.) and 3 contracts were selected.
The total area of Israel was divided into 8 capturing zones and each contractor was given a zone to start with, winning the next zone after the successful compliance of the production.
The aerial capturing resolution was set to 20cm to produce the mapping products that meets the government and public needs.

Regarding the objectives of the standard and after 3 years running the bid we can conclude that the standard objectives are achievable.

The next step should be to expand the standard to higher geospatial resolution for smaller project areas such as municipal areas under massive construction development. A special attention needs to be given to oblique imagery capturing and 3D photo realistic models in order to support decision making in the era of urban planning.

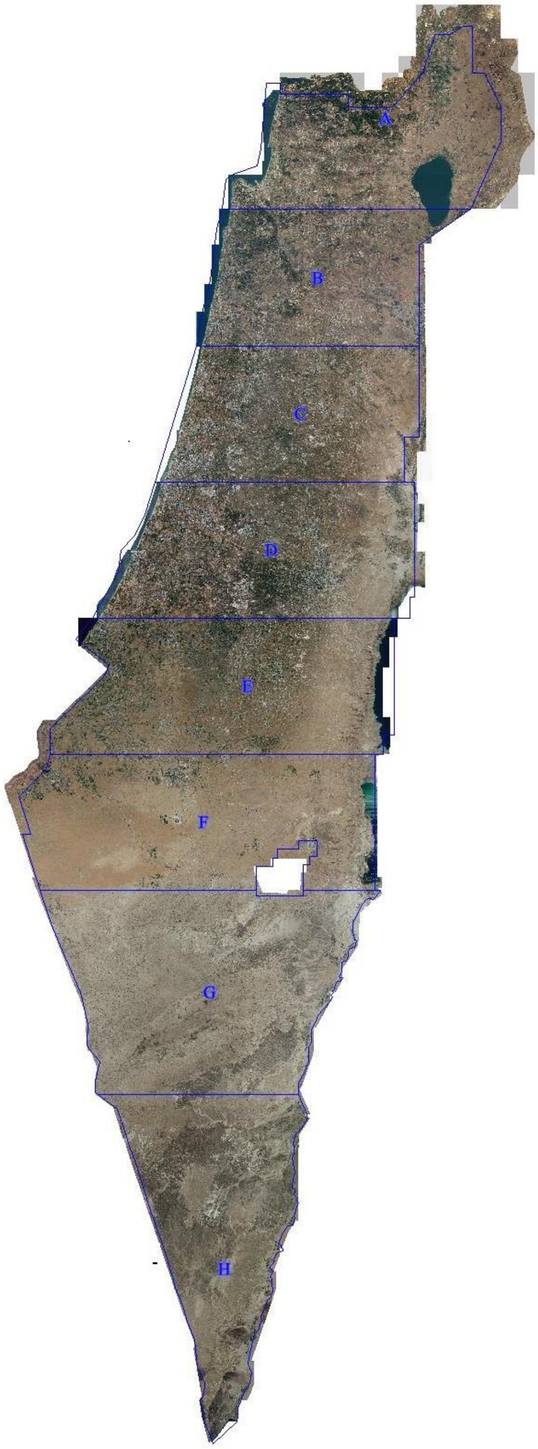

***Figure 4**: the 8 areas division of Israel and the 2021 ortho cover*

REFERENCES

ASPRS, Hussain M., Bethel J., (2004) Manual of Photogrammetry, fifth Edition Chapter 15, Project and Mission Planning

ASPRS (2014) ASPRS Positional Accuracy Standards for Digital Geospatial Data Ed.1, Ver. 1.0. doi: 10.14358/PERS.81.3.A1-A26

Felus Y., Keinan E., Regev R., (2013) Regulations in the field of Geo-Information, International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-7/W2, ISPRS2013-SSG, Turkey doi:10.5194/isprsarchives-XL-7-W2-87-2013

Felus Y. , Keinan E. , Benhamu M. ,Regev R., Zalmanzon G. (2016), The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLI-B1, 2016 XXIII ISPRS Congress, Prague, Czech Republic
doi: 10.5194/isprsarchives-XLI-B1-179-2016

Kapnias D., Milenov P. and Kay S. (2008), Guidelines for Best Practice and Quality Checking of Ortho Imagery at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC48904/10133.pdf
DOI 10.2788/36028

Land information New Zealand (2014), Guidelines on geo-referencing and orthorectification of historic aerial imagery at: https://www.linz.govt.nz/system/files_force/media/file-attachments/Georeferencing%20and%20orthorectification%20guidelines%202014%20.pdf

Land information New Zealand (2013), Specifications relating to the acquisition of orthophotography at:
https://www.linz.govt.nz/system/files_force/media/file-attachments/SpecificationRelatingAcquisitionOrthophotography.doc

Annex 1

Geospatial products levels		GSD (cm)	Largest scale		Contour line interval (m)	GCP RMSE (m)		AT RMSE (m)	
Horizontal	Vertical					East/North	Vertical	East/North	Vertical
3	3	2.5	1:250		0.25	0.030	0.025	0.05	0.04
4	4	5	1:500		0.50	0.065	0.050	0.10	0.08
5	5	7.5	1:1,000		1.00	0.125	0.100	0.20	0.16
6	6	10	1:1,250		1.25	0.150	0.125	0.25	0.2
7	7	12.5	1:2,500		2.50	0.315	0.250	0.50	0.4

Table 2: Accuracy level, GCP and AT Accuracy